Name: _____ Class: _____ Date: _____

Two-Dimensional Motion and Vectors

Problem B

RESOLVING VECTORS

PROBLEM

Find the components of the velocity of a helicopter traveling 95 km/h at an angle of 35° to the ground.

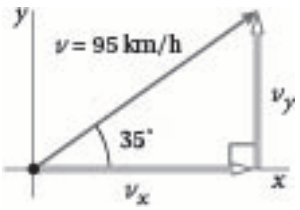
SOLUTION

1. **DEFINE**

Given: $v = 95$ km/h $\quad \theta = 35°$

Unknown: $v_x = ?$ $\quad v_y = ?$

Diagram: The most convenient coordinate system is one with the *x*-axis directed along the ground and the *y*-axis directed vertically.



2. **PLAN** **Choose an equation or situation:** Because the axes are perpendicular, the sine and cosine functions can be used to find the components.

$$\sin\theta = \frac{v_y}{v}$$

$$\cos\theta = \frac{v_x}{v}$$

Rearrange the equations to isolate the unknowns:

$$v_y = v \sin\theta$$

$$v_x = v \cos\theta$$

3. **CALCULATE** **Substitute the values into the equations and solve:**

$$v_y = (95 \text{ km/h})\ (\sin 35^\circ)$$

$$\boxed{v_y = 54 \text{ km/h}}$$

$$v_x = (95 \text{ km/h})\ (\cos 35^\circ)$$

$$\boxed{v_x = 78 \text{ km/h}}$$

4. **EVALUATE** Because the components of the velocity form a right triangle with the helicopter's actual velocity, the components must satisfy the Pythagorean theorem.

$$v^2 = v_x^2 + v_y^2$$
$$(95)^2 = (78)^2 + (54)^2$$
$$9025 \approx 9000$$

The slight difference is due to rounding.

ADDITIONAL PRACTICE

1. The distance from an observer on the plain to the top of a nearby mountain is 5.3 km, and the angle between this line and the horizontal is 8.4°. How tall is the mountain?
2. A bowling ball is released at the near right corner of a bowling lane and travels 19.1 m at an angle of 3.0° with respect to the lane's length. The ball reaches the far left corner of the lane, where it knocks over the "7" pin. What is the width of the lane?
3. A truck drives up a hill with a 15° incline. If the truck has a constant speed of 22 m/s, what are the horizontal and vertical components of the truck's velocity?
4. A hot-air balloon descends with a velocity of 55 km/h at an angle of 37° below the horizontal. What is the vertical velocity of the balloon?
5. A billiard ball travels 2.7 m at an angle of 13° with respect to the long side of the table. What are the components of the ball's displacement?
6. One hole at a certain miniature golf course extends for about 60 m. A golf ball on this hole travels with a velocity of 1.20 m/s at 14.0° east of north. What are the eastern and northern components of the ball's velocity?
7. The Very Large Array in western New Mexico consists of several radio telescopes that can be rearranged along railroad tracks. The largest of these arrangements has the telescopes positioned in a "Y" pattern for 18 km along three separate tracks. Suppose an electrician inspects the instruments in each antenna from the end of the northern track to the end of the southwestern track. If the electrician's resultant displacement is 31.2 km at 30 0° west of south, what are the southern and western components of the displacement?

8. Barnard's Star is the closest star to Earth after the sun and the triple star Alpha Centauri. Barnard's Star has a velocity of 165.2 km/s at an angle of 32.7° away from its forward motion. What are the forward and side components of this velocity?
9. What are the horizontal and vertical components of a cat's displacement when the cat has climbed 5 m directly up a tree?
10. A certain type of balloon is designed to ascend rapidly. Suppose this balloon has a velocity 13.9 m/s at 26.0° above the horizontal and 24.0° east of north. What are the upward, northern, and eastern components of the balloon's velocity? (HINT: Draw horizontal and vertical right triangles whose sides represent the velocity's components.)